

Results of a Field Test Using R-407C in Split System Heat Pumps

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ABSTRACT

This paper discusses the results of a field test to determine implications of an R-407C replacement of R-22.

A change of refrigerants precipitates other changes in materials, component selection, and processing. In addition, thermodynamic properties are different. Consequently, the effects on durability, thermal performance, humidity control, servicing, and manufacturability were questioned.

The field test addressed many of these questions. Anticipated changes in manufacturing processes were implemented on the production line. Contractors were educated on the differences in the refrigerant. Data were obtained by refrigerant, lubricant, and component tear down analysis. Experiential information was derived from feed back of contractors and home owners, as well as multiple site visits.

Generally, the field test has demonstrated that by following a few basic rules, the industry can anticipate use of R-407C with satisfactory results. However, the surprising appearance of a contaminate precipitant indicates the need for more investigation into long term effects.

INTRODUCTION

Unitary HVAC equipment has relied on the HCFC R-22 for many years. With phase out eminent, the HVAC industry seeks viable alternative refrigerants. Of those being considered, R-407C has risen to the forefront as a potential drop-in replacement for R-22.

While laboratory tests with this blend have been carried out by various organizations, field testing has been limited. A need to gain experience with manufacturing, installation, servicing, and field

operation was recognized and resulted in a joint effort by Lennox Industries, Inc., Copeland Corp., and Du Pont Fluoroproducts. In 1993 a field test was initiated to gain some experience with R-407C and POE lubricants. This paper reviews that testing and the results.

FIELD TEST DESCRIPTION

The main objectives of the field test were the following: 1) validate R-407C refrigerant and POE lubricant processing procedures for both the factory and the field, 2) monitor the installed units to assess compatibility of the refrigerant and lubricant with the system, 3) obtain input from the field on issues or problems associated with installation, servicing, operation, sound levels, etc., 4) return and analyze components after sufficient test time to determine any long term effects of the refrigerant or lubricant.

R-407C closely matches system performance of R-22. It has zero ozone potential, low global warming potential, and is non-flammable. It operates at a slightly higher pressure, is zeotropic (different composition ratios in liquid and vapor phases), and has the evaporating and condensing "glide" characteristic. The original composition of this ternary blend consisted of 30% R-32, 10% R-125, and 60% R-134a by weight. During the course of the field test this refrigerant was replaced with Du Pont's current blend ratio.

The compressor used for the field testing was a scroll manufactured for use with R-407C refrigerant. Due to the immiscibility of HFC's and mineral oil, Copeland selected the Mobil EAL Arctic 22 lubricant which is a polyol ester (POE) oil. Also, each compressor had a special oil drain fitting installed on the side of the can in a position which allowed limited oil withdrawal.

Lennox manufactured 3 ton split heat pump systems for the field test. These were supplied with

Alco filter-driers specified for use with this HFC and the POE oil. Also, Alco thermal expansion valves (TXV's), with a setting based on laboratory testing of R-407C, were provided. A new indoor coil and new line sets were installed with each heat pump.

POE oil has an affinity for moisture and will begin to break down if too much moisture is absorbed. This was a concern during manufacture, installation, and servicing of the systems. Compressors were not opened to the atmosphere until just before brazing into the system.

Another area of concern centered around the charging techniques with this ternary refrigerant blend. Since it is a zeotrope, the composition varies between the liquid and vapor phases. In order to maintain the proper composition, the units had to be liquid charged in the factory and in the field (if necessary). Also, the "glide" characteristic required determining superheat from the "Dew Point" and subcooling from the "Bubble Point" of the refrigerant. This required some education of the dealers.

The field test consisted of ten systems installed at residential sites. Eight were installed in the Dallas, Texas area, one in Phoenix, Arizona, and one in Fargo, North Dakota. Data collection included oil and refrigerant samples, and observations and feedback from the participants (homeowners) as well as the dealer. The units were returned to standard R-22 configuration at the end of the field test, and compressors, driers, expansion valves, and line sets from the test were analyzed for long term effects.

TEST RESULTS

The systems were installed in the spring of 1993 by approved dealers. All of the installations went well.

Oil samples were taken approximately 24 hours after each system was installed. Most of these showed moisture levels higher than the recommended 50 PPM; thus, the need for stringent processes (and very good drier action) with this lubricant were made apparent. Other than that, the samples indicated no problems.

Based on comments from the participants, the systems provided the cooling and heating performance required. No problems occurred that

were associated with the alternate refrigerant and lubricant.

As the field test progressed, Du Pont had reformulated the refrigerant blend for SUVA®9000: 23% R-32, 25% R-125, 52% R-134a by weight. Also, Copeland had a reformulated lubricant with improved wear characteristics. Because of these developments, the compressors, oil, and refrigerant were replaced in November of 1993. No driers were changed. Although this is not good service practice, we wanted to push the test closer to the edge in the area of moisture.

After the units had been running 24 hours, an oil sample was taken. Moisture levels were better, although a few were still higher than the desired 50 PPM. This sample established a baseline for comparison.

All units operated well through the winter months (heating mode), and no performance problems were reported.

Oil samples were taken again in April of 1994. Analysis of these second samples looked very promising; the moisture levels were reduced from the initial oil samples (samples taken after compressor change out). The moisture content measured in the two analyses are compared in Figure 1 for the Dallas area sites. The lower levels showed that the filter drier was performing as it should.

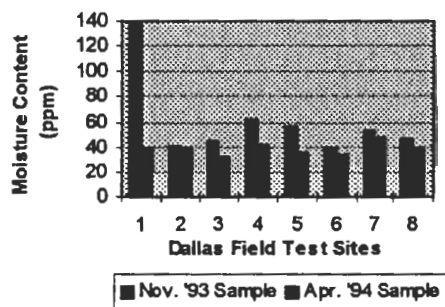


Figure 1 Oil Sample Analysis - Moisture

The total acid number was also measured from the samples and the results are shown in Figure 2. These levels also looked good. This is a further sign that moisture levels are being controlled and no significant oil breakdown is occurring.

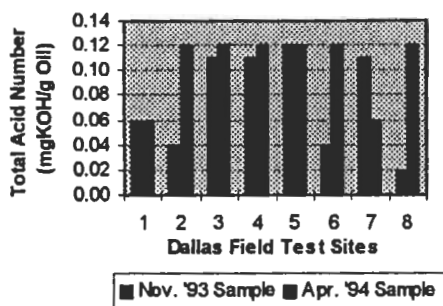


Figure 2 Oil Sample Analysis- Acid

The metals content for both sets of samples was very low and thus indicated no signs of premature compressor wear.

Refrigerant samples were also taken in April of 1994. Some of the refrigerant samples revealed very unexpected compositions; we suspected the sampling technique was to blame. A subcooled liquid refrigerant sample must be obtained into a container which closely matches the required sample volume to insure accurate composition results. A second, careful sampling from the field sites in question produced favorable results. The composition of each constituent generally measured $\pm 2\%$ from the original blend composition. These slight changes in composition were attributed to error inherent in the sampling and measurement of the refrigerant. Based on the measurements, no significant composition changes had occurred in the systems.

Operation throughout 1994 and 1995 continued to be very successful. The participants remained satisfied with the performance of the systems. However, there were occasional reports of mild weather high pressure switch trips.

There was an attempt to take another oil sample in early 1995 for comparative analysis. Due to the oil level being below the oil sampling port on some compressors, we were able to get oil from only half of the compressors. Of the samples which we were able to get, the volume of oil was insufficient to measure the acid and moisture content was not significantly different from earlier measurements.

In mid 1995, the first of the field test units was converted back to R-22 w/ mineral oil. It was at this time that we noticed the presence of an unusual contaminate. By the end of 1995, all except three sites were converted back to R-22. These three sites

will remain operating on R-407C for the foreseeable future.

The source and implications of the contaminate are still under investigation. It seems to be associated with high discharge temperatures. A thorough understanding of this phenomena is a prerequisite for confidence in a product's long term performance and reliability.

CONCLUSION

Without exception, the participants were very satisfied with the thermal performance of the systems.

Several points of interest are worth noting from the field test:

1. Moisture levels are a concern with the POE oil but appear to be controllable with the proper filter-drier and manufacturing, installation, and service practices.
2. Service personnel seemed to adapt easily to the "glide" characteristics.
3. Care must be taken when extracting refrigerant samples for analysis. Internal volume of the sample containers should be close to the required volume of the sample and samples must be subcooled liquid.
4. There were reports of high pressure switch trips. Three of those reporting sites were traced back to poor air volumes across the indoor coil. One other site remains mysterious and possible causes are still being investigated. It should be noted that the pressure switch was set for R-22 operation and R-407C operates at a slightly (approx. 20 - 30 PSI) higher pressure than R-22.
5. Deposition of a mysterious contaminate inside the system is still under investigation.